

Claims

1. A tip structure that includes a single-crystalline substrate and a single-crystalline tip epitaxial to the substrate,

wherein

the axis of the tip forms a given angle in respect to the vertical that passes through its basis.

2. The tip structure according to the point 1, **wherein** the substrate has a plane surface.

3. The tip structure according to the point 1, **wherein** the substrate represents a single-crystalline tip epitaxial to a plane single-crystalline surface.

4. The tip structure according to any of the points 1-3, **wherein** a single point of the substrate serves as a basis for at least two tips.

5. The tip structure according to any of the points 1-4, **wherein** the tip has a shape that includes at least one step and two links, the axis of each subsequent link can form its own angle in respect to the axis of the previous link.

6. The tip structure according to the point 5, **wherein** at least one of the steps serves as a basis for at least two links, at least one of them can be not epitaxial to the previous one.

7. The tip structure according to any of the points 5 and 6, **wherein** at least one of the links is formed by a nanotube.

8. The tip structure according to the point 7, **wherein** the nanotube is combined by layers of different materials, one of them being carbon.

9. The tip structure according to any of the points 5-8, **wherein** at least one of the links is formed by at least one atomic row.

10. The tip structure according to any of the points 1-9, **wherein** at least one tip has a particle on its top that contains, in addition to the tip material, at least one more chemical element, the particle can be coated by a film of this or another element.

11. The tip structure according to the point 10, **wherein** at least one chemical element, that is contained in the particle, participates in the growing of the tip structure, and the particle can be coated by a film of this or another element.

12. The tip structure according to any of the points 10, 11, **wherein** chemical functional groups are deposited in the film.

13. The tip structure according to any of the points 1-8, **wherein** a non-magnetic tip has a flat top, a monodomain magnetic particle of a conical shape is placed on the flat top, basis of the particle contacting with the flat top.

14. The tip structure according to any of the points 1-8, **wherein** an electroconductive tip has a flat top perpendicular to the axis of the tip, the flat top is coated by a dielectric film, a p-n junction in the upper part of the tip being parallel and close to the flat top.

15. A tip structure that includes a substrate and a single-crystalline tip

wherein

the tip is not epitaxial to the substrate.

16. The tip structure according to the point 15, **wherein** the axis of the tip forms an angle in respect to the vertical that passes through its basis.

17. The tip structure according to any of the points 15 and 16, **wherein** the substrate has a plane surface.

18. The tip structure according to any of the points 15-17, **wherein** a single-crystalline tip epitaxial to a plane single-crystalline surface serves as the substrate.

19. The tip structure according to any of the points 15 – 18, **wherein** one point of the substrate serves as a basis for at least two tips.

20. The tip structure according to any of the points 15-19, **wherein** the tip has a shape that contains at least one step and two links, the axis of each subsequent link has its own angle in respect to the axis of previous link.

21. The tip structure according to the point 20, **wherein** at least one step serves as a basis for two links, at least one of them can be not epitaxial to the previous one.

22. The tip structure according to the points 20 and 21, **wherein** at least one of the links is formed by a nanotube.

23. The tip structure according to the point 22, **wherein** the nanotube is combined of layers of different materials, one of them being carbon.

24. The tip structure according to any of the points 20-23, **wherein** at least one of the links is formed by at least one atomic row.

25. The tip structure according to any of the points 15-24, **wherein** at least one tip has a particle on its top that contains, in addition to the tip material, at least one more chemical element, the particle being coated by a film of this or another element.

26. The tip structure according to the point 25, **wherein** at least one chemical element, that is contained in the particle, participates in the growing of the tip structure, and the particle can be coated by a film of this another element.

27. The tip structure according to any of the points 25, 26, **wherein** chemical functional groups are deposited on the film.

28. The tip structure according to any of the points 15-24, **wherein** a non-magnetic tip has a flat top, a monodomain magnetic particle of a conical shape is placed on the flat top, basis of the particle contacting with the flat top.

29. The tip structure according to any of the points 15-24, **wherein** an electroconductive tip has a flat top perpendicular to its axis, the flat top is coated by a dielectric film, a p-n junction in the upper part of the tip being parallel and close to the flat top.

30. A method for preparation of the tip structure by means of epitaxial growing of the tip according to the vapor-liquid-solid mechanism on a substrate by deposition from a vapor-gaseous and/or gaseous mixture with using of at least one metallic solvent,

wherein

the tip structure is growing as at least one tip so that the axis of the tip forms a given angle in respect to the vertical that passes through its basis.

31. The method according to the point 30, **wherein** as the substrate a single-crystalline wafer oriented along a certain crystallographic plane is used, this single-crystalline wafer allows to prepare the tip structure as at least one tip epitaxial to the substrate under an angle to its surface.

32. The method according to the point 30, **wherein** a single-crystalline tip epitaxial to a flat single-crystalline surface is used as the substrate.

33. The method according to any of the points 30-32, **wherein** the tip structure of the points 3-14 is prepared by a changing the growing temperature and/or concentrations of compounds in the vapor-gaseous or gaseous mixture, and/or

pressures of the vapor-gaseous or gaseous mixture, and/or by addition of at least one metallic solvent and/or its evaporation.

34. The method according to any of the points 30-33, wherein after the growing the tip structure a diffusion of at least one chemical element into the structure is performed with conservation of the structure of at least one metallic solvent.

35. The method according to any of the points 30-34, wherein after the preparation of the structure it is immersed into an amorphous material, the composite obtained is polished together with at least one apex of the tip structure until formation of a flat surface, and the amorphous material can be etched away.

36. The method according to any of the points 30-35, wherein, after the etching away the amorphous material, a diffusion of at least one chemical element into the material of the tip structure is performed.

37. The method according to any of the points 30-36, wherein a diffusion of at least one chemical element into at least one metallic solvent is performed.

38. The method according to the point 37, wherein by etching off the material that has diffused into at least one metallic solvent, the metallic solvent is removed.

39. The method according to any of the points 30-38, wherein at least one chemical element is evaporated onto all the surface of the tip structure.

40. The method according to the point 39, wherein a part of the evaporated chemical element is removed by an etching off the diffusion layer from the surface of the tip structure, or by etching off the amorphous layer with conservation of the chemical element on at least one apex.

41. The method according to any of the points 30-40, wherein the epitaxial growing of the tip structure is implemented, and by a changing the growing temperature and/or concentrations of compounds in the vapor-gaseous or gaseous mixture, and/or pressures of the vapor-gaseous or gaseous mixture, and/or by addition of at least one metallic solvent and/or its evaporation a step and/or a plateau on at least one apex is created, after that the solidified globule can be removed.

42. The method according to any of the points 34-41, wherein at least one of the procedures described in the points 33-41 is used at least one more time.

43. The method according to any of the points 39-41, wherein at least one time a magnetic material is used as the evaporating one, the magnetic particle formed

is sharpened by a bombardment with accelerated ions, and a monodomenization of the particle can be performed.

44. The method according to the point 43, **wherein** the monodomenization is performed by enduring of the particle in a constant magnetic field of a certain direction.

45. The method according to the point 43 and 44, **wherein** the monodomenization is performed at a high temperature of the magnetic particle, the temperature can be reached by passing a field-emission current through the tip structure.

46. A method for preparation of at least one tip structure by directional growing according to the vapor-liquid-solid mechanism on a substrate at deposition from a vapor-gaseous and/or gaseous mixture with using of at least one metallic solvent,

wherein

the tip structure is grown non-epitaxially to the substrate.

47. The method according to the point 46, **wherein** the tip structure is created according to the points 15-29.

48. The method according to any of the points 46 and 47, wherein a hollow is created in the substrate for the growing of the tip

49. The method according to the point 48, **wherein** the hollow has a shape that corresponds to the crystallographic structure of the tip material.

50. A source of electrons that includes a substrate, a field emitter, and a source of charge carriers,

wherein

the field emitter represents a tip structure according to the points 1-11 and 15-26.

51. A cantilever for scanning probe devices that includes a holder, a lever and a probe,

wherein

the tip is implemented as a tip structure according to the points 1-29.

52. A cantilever for scanning probe devices that includes:

at least two alternating plane-parallel layers of conducting materials separated by non-conducting layers;

at least one bending section – a lever implemented from a first conducting layer;

a probe placed on the lever;

at least one electrode – a section of a second conducting layer arranged along the lever at the side opposite to the probe;

wherein

the electrode contains a means for suppression of non-resonant oscillations of the lever, the means representing a feedback system.

53. The cantilever according to the point 52, **wherein** the probe is implemented as a tip structure according to the points 1-29.

54. The cantilever according to any of the points 52 and 53, **wherein** the electrode contains a means for controlling the lever deflections, and/or a means for a forced deflection of the lever of its initial position, and/or a means for modulation of the resonant lever oscillations.

55. The cantilever according to any of the points 52-54, **wherein** at the side of the lever that is opposite to the electrode side of the lever is arranged another electrode implemented from an additional conducting layer and contained a means for controlling lever deflections, and/or a means for a forced lever deflection of its initial position, and/or a means for modulations of resonant oscillations of the lever, and/or a means for suppression of non-resonant oscillations of the lever, the system being acted as a feedback one.

56. The cantilever according to any of the points 52-55, **wherein** between the lever and at least one electrode a vacuum gap exists, the gap can be filled by liquid and/or plastic material that allows a mutual shifting of the lever and the electrode relative to each other.

57. The cantilever according to any of the points 52-56, **wherein** the lever has a Π - and/or V-shape and/or longitudinal cavity, the cavity forming lever arms.

58. The cantilever according to any of the points 52-57, **wherein** the lever has a piezoresistive layer and/or semiconductor layer doped up to the p^{++} -conductivity.

59. The cantilever according to any of the points 57 and 58, **wherein** the lever arms separated by a longitudinal section has doped layers of n-, n⁺-, p-, p⁺ type conductivity.

60. The cantilever according to any of the points 57 and 59, **wherein** one of the lever arm serves as a drain, another lever arm serves as a source for a control system, the arms being separated by a lever section that has another conductivity, one of the electrodes implements a function of a gate being a means of a control.

61. A scanning probe device that includes:

a cantilever containing at least one lever, at least one controlling electrode and/or at least one electrode for controlling lever deflections of an initial position;

a system for regulation and controlling the lever deflections

wherein

the lever is implemented according to any of the points 52-60.

62. The scanning probe device according to the point 61, **wherein** one electrode is placed along at least two levers.

63. The scanning probe device according to any of the points 61 and 62, **wherein** the system for controlling the lever deflections represents a system for registration of the changes of the capacity between the lever and at least one electrode and/or of the contour quality, that includes its capacity, for each lever being chosen its own control frequency.

64. The scanning probe device according to any of the points 61-63, **wherein** the control system includes a system for the forced deflection that can be electrostatic and/or electromagnetic one.

65. The scanning probe device according to any of the points 61, 63, and 64, **wherein** at least two electrodes are placed along the same lever.

66. The scanning probe device according to the point 65, **wherein** the system for controlling the lever deflections represents a system for registration of the changes of the capacity between the arms of the lever, separated by a longitudinal section, and at least one electrode, for a controlling the lever rotation relative to a longitudinal axis a specific frequency being chosen for each of the lever arms.

67. A method for preparation of a cantilever for scanning probe devices that includes

- a formation of a composite wafer consisting of at least two alternating plane-parallel layers of conducting materials separated by non-conducting layers;
- a formation of at least one lever from the first conducting layer;
- a creation of a probe on the lever

wherein

at least one electrode arranged along the lever at a side opposite to the probe is formed from the second conducting layer.

68. The method according to according to the point 67, **wherein** the probe is implemented as the tip structure according to the points 1-14 and 15-29.

69. The method according to any of the points 67 and 68, **wherein** the composite wafer is prepared by bonding of wafers and/or mechanical and/or chemical removal of parts of the wafers with conservation of thin layers having a given thickness.

70. The method according to any of the points 67-69, **wherein** at least one conducting layer and/or at least one non-conducting layer of the composite wafer are prepared by a deposition of a material and/or materials.

71. The method according to any of the points 67-70, **wherein** an electrode with contact outputs/terminals and/or a mechanico-electric structure for systems of control and/or regulation is formed on at least one conducting layer before the bonding and/or between bonding stages and/or after the bonding.

72. The method according to any of the points 71 and 72, **wherein** an electrode with contact outputs/terminals and/or a mechanico-electric structure for systems of control and/or regulation is formed on at least one conducting layer before the deposition and/or between the deposition stages and/or after the deposition of the material and/or materials.

73. The method according to any of the points 67-72, **wherein** at least one conducting layer and/or at least one non-conducting layer are used at the preparation of the cantilever as technological stop-layers.

74. The method according to any of the points 67-73, **wherein** the probe is implemented as the tip structure according to points 30-49.